

Figure 1: Sequential Flow of Events

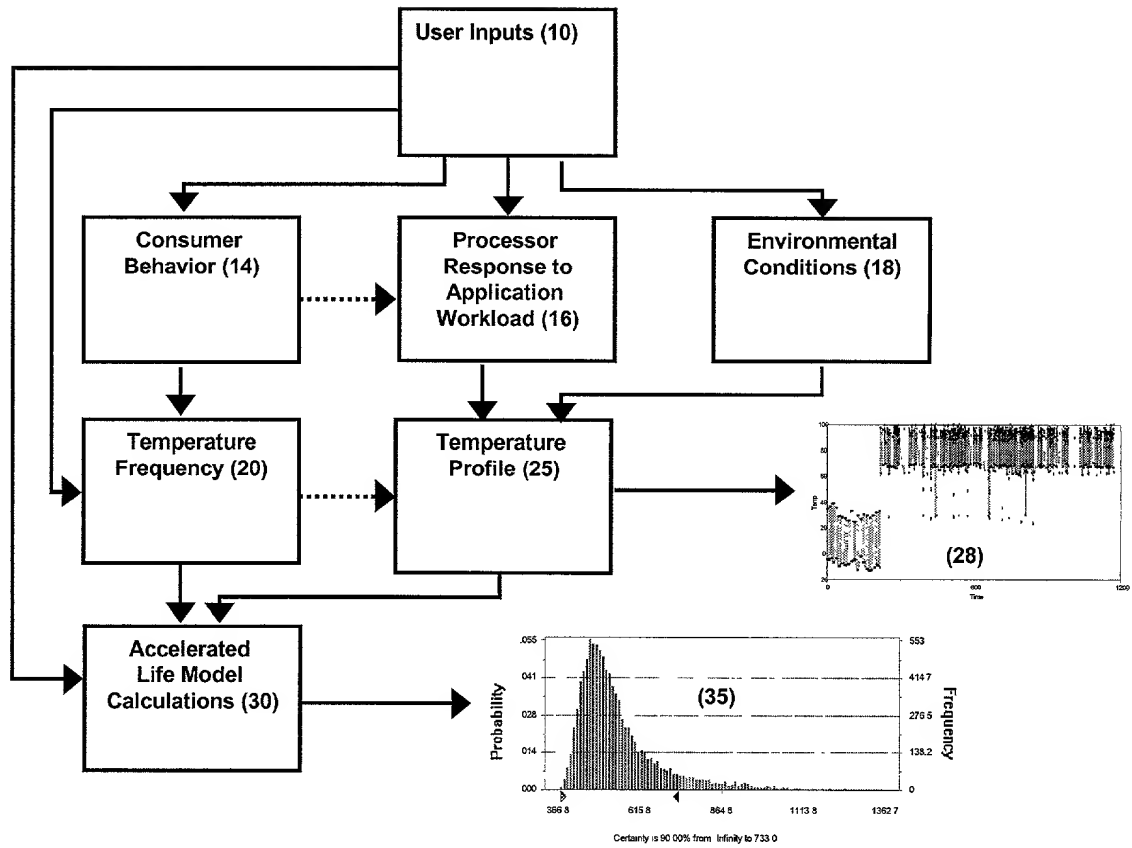


Figure 2: Depiction of Graphical User Interface for Design Inputs

(50)

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Probabilistic Reliability Test Calculator

Number of Trials to Run (52)

Max Temp at failure location (Degrees C) (54)

Delta-T Stress Chamber

Temp Cycle (62)

Mean (Deg C) (64)

Std Dev (Deg C) (66)

Distribution = Normal

(60)

Thermal Design Power (watts) (70)

Leakage Power (watts) (72)

Failure Mechanism (74)

Power Law Coefficient (76)

Market Segment (80)

Shipping Path (Flow to OEM) (82)

Duration (Years) (84)

Output tab

☐ Rename results worksheet?

OK Cancel

Figure 3: Representative Temperature Response

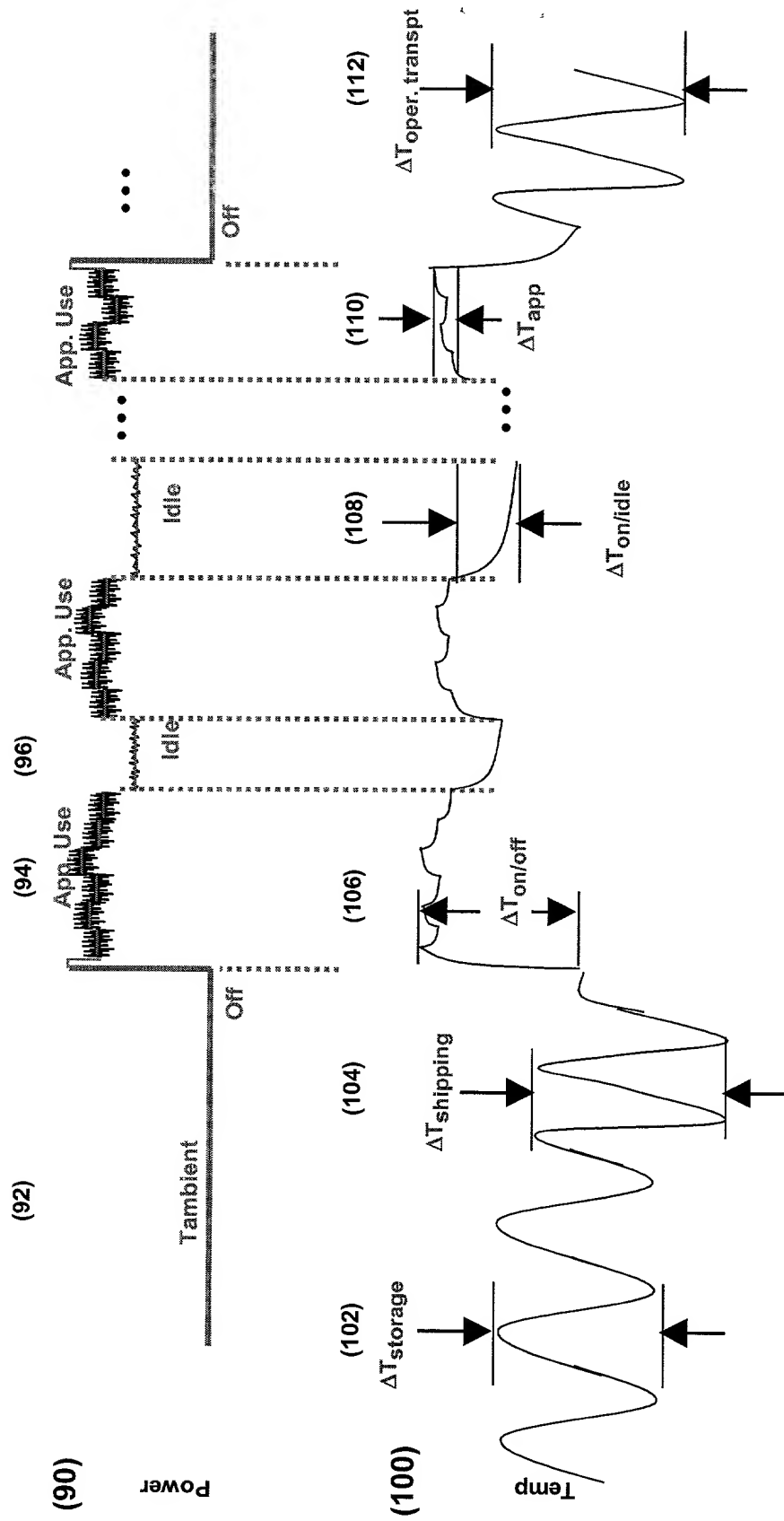


Figure 4: Modification to Coffin-Manson empirical Model

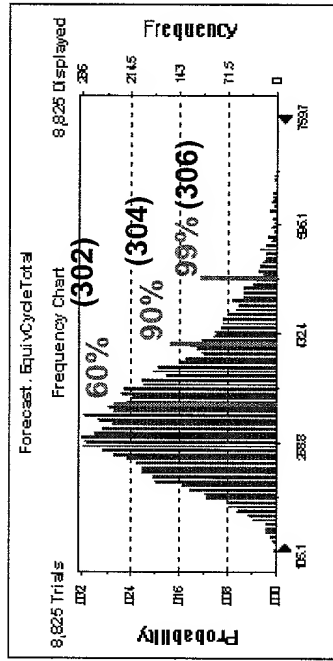
$$\begin{aligned}
 (205) \quad N_{Accel_Total} &= N_{Accel_Storage} + N_{Accel_Shipping} + N_{Accel_Operating} \quad (206) \quad (207) \quad (208) \\
 &\quad \downarrow \quad \downarrow \quad \downarrow \\
 N_{Use_Stor.} &\cdot \left(\frac{\Delta T_{Storage}}{\alpha_{Storage} \cdot \Delta T_{Accel}} \right)^n \quad (210) \\
 N_{Ship,air} &\cdot \left(\frac{\Delta T_{Ship,air}}{\alpha_{Ship,air} \cdot \Delta T_{Accel}} \right)^n + N_{Ship,grnd} \cdot \left(\frac{\Delta T_{Ship,grnd}}{\alpha_{Ship,grnd} \cdot \Delta T_{Accel}} \right)^n \quad (211) \quad (212) \\
 N_{Use_On/Idle} &\cdot \left(\frac{\Delta T_{Use_On/Idle}}{\alpha_{On/Idle} \cdot \Delta T_{Accel}} \right)^n + N_{Use_App} \cdot \left(\frac{\Delta T_{Use_App}}{\alpha_{Use_App} \cdot \Delta T_{Accel}} \right)^n + N_{Oper_transport} \cdot \left(\frac{\Delta T_{Oper_transport}}{\alpha_{Op.,trans} \cdot \Delta T_{Accel}} \right)^n \quad (213) \quad (214) \quad (215)
 \end{aligned}$$

Figure 5: Input and output data from the Accelerated Life Testing algorithm

(300)

Temp Cycle Model Inputs	Value
# of simulation trials	8825
T Max at failure location (degrees C)	90.0 C
Temp Cycle	B
Mean (DT) Stress Chamber (degrees C)	190.0 C
Stdev (DT) Stress Chamber (degrees C)	200 C
Thermal Design Power (watts)	50
Leakage Power (watts)	5
Failure Mechanism	Solder Ball Fatigue
Power Law Coefficient	2.00
Failure Mechanism Zone	B
Market segment	CPU Mobile
Shipping lane (flow to DEM)	Standard
Duration (years)	7 years

(320)



(331)

(332)

(333)

(334)

(335)

(336)

(337)

(338)

(339)

TEMP CYCLE STATS	Cycles	Min Temp	Max Temp	Delta Temp mean	Delta Temp Stdev	Equip Stress Cycles (80%)	Equip Stress Cycles (90%)	Equip Stress Cycles (99%)	Total Damage Contribution
Storage	100	-40.00	80.00	20.00	3.00	30.0	50.0	70.0	9.1%
Shipping by ground	50	-40.00	80.00	20.00	3.00	40.0	60.0	80.0	12.1%
Shipping by air	50	-5.00	30.00	5.00	3.00	50.0	70.0	90.0	15.2%
Operating, use/ride	1,000	35.00	80.00	30.00	4.00	80.0	80.0	100.0	18.2%
Operating, application use	100,000	85.00	80.00	0.00	1.00	70.0	80.0	110.0	21.2%
Operator Transport	5,000	-20.00	80.00	20.00	3.00	80.0	100.0	120.0	24.2%
						330	450	570	

(341)

(342)

(343)

(344)

(345)

(346)

POWER CYCLE STATS	Cycles	Min Temp	Max Temp	Delta Temp mean	Delta Temp Stdev
Power on/off cycles	10,000	90.00	50.00	50.00	4.00

$$\begin{aligned}
 & N_{\text{storage}} \cdot \left[\frac{\Delta T_{\text{storage}}}{\alpha_{\text{storage}} \cdot \Delta T_{\text{stress}}} \right] + N_{\text{ship,air}} \cdot \left[\frac{\Delta T_{\text{ship,air}}}{\alpha_{\text{ship,air}} \cdot \Delta T_{\text{stress}}} \right] + N_{\text{ship,grnd}} \cdot \left[\frac{\Delta T_{\text{ship,grnd}}}{\alpha_{\text{ship,grnd}} \cdot \Delta T_{\text{stress}}} \right] + N_{\text{application use}} \cdot \left[\frac{\Delta T_{\text{application use}}}{\alpha_{\text{app_use}} \cdot \Delta T_{\text{stress}}} \right] + N_{\text{on/idle}} \cdot \left[\frac{\Delta T_{\text{on/idle}}}{\alpha_{\text{on/idle}} \cdot \Delta T_{\text{stress}}} \right] \\
 & + N_{\text{op,transport}} \cdot \left[\frac{\Delta T_{\text{op,transport}}}{\alpha_{\text{op,transport}} \cdot \Delta T_{\text{stress}}} \right]
 \end{aligned}$$

(310)

Figure 6: Illustration depicting how component location influences the size and magnitude of temperature fluctuations

